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# An Assessment of the Horizontal Accuracy of Interim Terrain Data

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April 1996





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**13. ABSTRACT** *(Maximum 200 words)*
Within the U.S. Army and throughout the private sector, the accuracy of Digital Topographic Data (DTD) is often taken for granted. Users assume terrain data to be accurate merely because of its digital nature. This report describes a study that was undertaken to determine the horizontal accuracy of Interim Terrain Data (ITD), a 1:50,000-scale terrain analysis data base. ITD is composed of vector features and associated attributes representing land cover characteristics. It is produced by the Defense Mapping Agency (DMA) and provided to the U.S. Army to support near-term requirements on an interim basis until more standardized data is available. Because of its interim nature, ITD may be digitized from hard copy source ("carto-controlled") or produced solely from photography ("photo-controlled"). No definitive accuracy statement is provided with the data.
This study was initiated in 1994 with the collection of ground coordinates for over 400 selected ITD features. Each feature was located in the field using a Precise Lightweight Global Positioning System Receiver (PLGR) in the Precise Positioning Service (PPS) mode ( 10-meter horizontal accuracy). Universal Transverse Mercator (UTM) coordinates obtained from the PLGR were annotated for each feature.(continued)

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The UTM coordinates for coincident features in the ITD digital files were subsequently extracted by GIS query to compare statistically the digital data with the field data, calculate the offsets, and determine the horizontal accuracy of the ITD. The potential accuracy differences between the carto- and photo-controlled ITD and the variability of natural vs. manmade features are also discussed.

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## ILLUSTRATIONS

## PREFACE

This study was performed during the period June 1994 to September 1995 under the supervision of Mr. Jeffrey Messmore, Chief, Special Studies Division, and Mr. Richard Herrmann, Director, Digital Concepts and Analysis Center.[1]

The authors would like to extend special appreciation to Mr. John Nedza, Geographic Information Lab, for the many hours of effort he provided during import of the raw Interim Terrain Data (ITD) data and subsequent conversion to Arc-Info coverages. His outstanding technical expertise greatly facilitated data analyses and played a critical role in the successful completion of this study.

The authors would also like to thank Mr. Bill Ryder, Special Studies Division, Digital Concepts and Analysis Center for his excellent terrain analysis support during the field collection; Professor Richard Scott, Rowan College, Glassboro, N.J. for advice and insight about the statistical processes used in the report; and Messrs. Robert Gormley and David Wu, Special Studies Division, Digital Concepts and Analysis Center for their work regarding research and compilation of the statistical analyses.

Mr. Walter E. Boge was Director, and Colonel Richard G. Johnson was Commander and Deputy Director of the Topographic Engineering Center at the time of publication of this report.

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[1]When this report was printed, Mr. Regis J. Orsinger was the Director of the Digital Concepts and Analysis Center.

# AN ASSESSMENT OF THE HORIZONTAL ACCURACY OF INTERIM TERRAIN DATA

## INTRODUCTION AND BACKGROUND

Interim Terrain Data (ITD) was first produced by the Defense Mapping Agency (DMA) in 1987. Production of this data was initiated to fill the Army's urgent need for a digital terrain analysis product in support of emerging topographic and Command and Control (C2) systems. Earlier, in 1984, the Army had documented a digital topographic data (DTD) requirement that encompassed all Army's known and anticipated tactical DTD requirements. However, production against this requirement, described as Tactical Terrain Data (TTD), was not scheduled to commence until 1996. In order to get similar data to Army users, DMA initiated production of a product called ITD, the goal of which was to fill the data void until TTD production came on line. Due to the interim nature of this data set and the use of more than one production method, DMA does not state a formal horizontal accuracy measure for this product.

As the center of expertise for DTD within the Army, TEC's Digital Concepts and Analysis Center (DCAC) formulated this study to characterize the horizontal accuracy of ITD. Knowledge of horizontal accuracy is important to the Army as well as other DOD users because it affects what are appropriate uses of the product. For example, is ITD as accurate as the Topographic Line Map (TLM), which may be used for targeting purposes, or is it only as accurate as a city graphic, which is not an appropriate source for targeting? Fortunately, along with the need to know ITD's horizontal accuracy, technology for rapid position determination has become available in the form of Global Positioning Systems (GPS). This technology was applied to determine the horizontal positions of well-defined ITD features.

The ITD is produced through two production processes; one is a hard-copy digitizing process, and the other is a pure photogrammetric production process. In the hard-copy process, tactical terrain analysis data base (TTADB) Mylar overlays (which are geo-registered to the corresponding 1:50,000-scale TLM's) are digitized, resulting in a "carto-controlled" ITD product. In the photogrammetric production process, imagery from DMA's feature extraction (FE) workstation is used, resulting in a "photo-controlled" ITD product. It should be noted that ITD cells from both of these widely divergent production processes are currently

distributed and in broad use. Carto-controlled cells make up the bulk of currently available ITD (≈840 of 1340 cells). The ≈500 remaining cells are photo-controlled.

## PURPOSE

The purpose of this study is to provide the Mapping Charting & Geodesy (MC&G) user community with information about the horizontal accuracy of ITD features. It is intended to give the user a level of confidence regarding ITD accuracy and to establish the utility of ITD for various applications. The study also identified accuracy differences between cartographic and photogrammetrically controlled ITD.

## METHODOLOGY & FIELD COLLECTION PROCEDURE

To assist with DCAC's ITD accuracy investigations, DMA provided ITD hard-copy plots, digital data, and associated TLM's for 10 cells in the continental U.S. (CONUS). The use of the hard-copy plots (from digital ITD) instead of the TTADB ensured that features identified for analysis would be represented in the digital data. Each of these plots covered approximately a 15-by 15-minute area. There were four photo-controlled cells in the Alamagordo/Las Cruces, NM area as well as six carto-controlled cells, two in the Ft. Bragg, NC area, and four in the vicinity of Ft. Hood, TX.

Scientists at DCAC reviewed the hard-copy plots and identified appropriate features for field reconnaissance. Two factors weighed heavily in the selection of features. The first factor was the existence of a distinguishable point on the ground (e.g., a road intersection, bridge, dam, or fence line). The second factor was accessibility for measurement of its horizontal placement. No vertical accuracy criteria, such as feature height or height above mean sea level, were considered. The selected features were then annotated on the coinciding 1:50,000 TLM for field use. They comprised a representative sample from the Transportation (TRANS), Surface Drainage (SD), Obstacles (OBS), and Vegetation (VEG) overlays, since these contained point or line features that were more easily recognizable in the field (see Appendix A). Features in the Surface Configuration and Soils overlays were not used for this study. Although important for many applications, these features are not easily distinguishable on the ground and are difficult to measure accurately.

Depending on the density of the data, 14 to 73 features on each of the 10 cells in the study areas were chosen for analysis. The number and variety of features chosen were those deemed necessary to assure representative coverage throughout each cell. More than 400 features were subsequently visited in the field. Each site was located by using a Precise Lightweight Global Positioning System Receiver (PLGR) in the Precise Positioning Service (PPS) mode (≈10 meter horizontal accuracy). Universal Transverse Mercator (UTM) coordinates derived from the PLGR were annotated for each.

## ANALYSIS

**Data Preparation.** The digital ITD files provided by DMA were partitioned on the provided media (9-track tape/6250 bpi) by individual sheet number and thematic layer(s). Related file header data was used to acquire descriptive information (metadata) about the individual data sets. The digital ITD files were archived in Standard Linear Format (SLF). Arc/Info (V. 7.0) was used to import the ITD-SLF files read from the tape. Upon import, the data was converted into Arc/Info coverages using the "SLFARC" command. Arc/Info's GIS functionalities enabled us to:

1. Identify and display selected features by thematic layer, feature type, and feature attributes.

2. Precisely extract UTM coordinates for selected features.

The Arc/Info coverages were geo-referenced in WGS-84 spherical geographic coordinates (LAT-LONG). Each coverage, maintained in single-coordinate precision (seven significant digits), was subsequently projected into a WGS-84 planar coordinate system (UTM) which was consistent with the GPS field collection coordinate system. Projection of coordinates from LAT-LONG to real-world UTM coordinates via the Arc/Info projection utilities was determined to be a virtually error-free process. Since both input and output coverages were stored in WGS-84 and required no additional datum transformations, the statistical significance of the root-mean-square (RMS) error was $\leq 0.010$. [NOTE: A perfect projection with an RMS error of 0.000 is not possible with real-world data.] Customized graphical user interfaces were developed using Arc/Info's Arc Macro Language (AML) to extract digital ITD feature coordinates.

**Digital ITD Coordinate Extraction.** UTM coordinates for selected features were extracted in order to compare the field data to the digital data, calculate the offsets, and thereby determine the horizontal accuracy of ITD. Thematic coverages for

each cell in the study area were displayed with the features appearing as unsymbolized centerline data. Next, those ground features visited in the field were identified in the digital file. A coordinate pair was extracted and recorded alongside the coordinate pair of the coincident ground feature. Finally, a series of statistical analyses was performed on both sets of coordinates.

**Statistical Analyses.** Coordinates for the photo-controlled and the carto-controlled ITD features were stored in different files, which were further delineated by eastings and northings. These files were then grouped by specific feature types (e.g., "surface drainage features from photo-controlled data"). Standard statistical measures such as mean, standard deviation, 95 percent confidence interval of the mean and a t-statistic with an associated critical value were calculated for each data file. The mean and standard deviation determine the size of the error. The 95 percent confidence interval indicates the potential magnitude of that error in future measurements. The t-statistic determines whether there is a significant difference between two populations (e.g., between the field data and the photo/carto-controlled ITD). Further explanations of the individual statistics are found in Appendix B.

## DISCUSSION/FINDINGS

During the field work, DCAC scientists visited 421 feature locations, collecting an easting and a northing at each for a total of 842 observations (combined photo-and carto-controlled data). A summary of statistics for this data is found in Table 1. Offsets ranged from a low of 0 meters (perfect correspondence between field & ITD coordinates) to a high of 339 meters. The average offset for all observations was 25 meters. When the GPS measurement error (Q value) of 10 meters is included, an average offset of 15 to 35 meters is established.

**Table 1. Summary of ITD Feature Coordinate Offsets**

| *# obs. (E&N)* | *OFFSET (m) Low Mean High* | *Std. Dev. (m)* | *#/% offset 50m* | *#/% offset 100m* | *Q* |
|---|---|---|---|---|---|
| 842 | 0 25 339 | 31 | 73/8.67 | 18/2.14 | 10 |

Q - measure of GPS error (circular) in meters
E&N - Eastings & Northings

Of the 842 total observations, 769 features (91.3 percent) were within 50 meters of their expected locations. This is within the expected accuracy of the 1:50,000 Class B TLM (50 meters circular @ 90 percent confidence), which is the only related product with a formal accuracy statement. Only 73 (8.7 percent) had field/ITD offsets above the 50 meter TLM baseline. Further examination revealed that 18 (2.1 percent) of the 73 had offsets more than 100 meters. As expected, 93 percent (68 of 73) of the offsets that were more than 50 meters occurred in cartographically controlled data. These errors were especially prevalent in the SD (e.g. dams, canals), OBS, and VEG coverages where 55 of the 73 offsets were observed. Potential rationales for the higher offsets in the carto-controlled SD, OBS, and VEG coverages (vs. photo-controlled ITD) lie in DMA's collection/symbolization techniques for this data as described below.

In carto-controlled ITD, horizontal positioning is keyed to a base map. Although many features are collected from imagery, they are still subject to a potential offset of 50 meters (map accuracy). Moreover, SD features, such as dams and canals, vegetation polygons, and especially obstacles are often displaced for symbolization purposes. Obstacles such as embankments, escarpments, ditches or road cuts may be substantially displaced to ensure the correct alignment of a stream or road bed. Moreover, it is often hard to determine the exact start or end point of an obstacle in the field.

Vegetation features are inherently characterized by their natural variability. Furthermore, ITD vegetation has a minimum areal size requirement resulting in the inclusion of many different vegetation types within a single polygon. The resulting boundaries can vary in these transition areas causing offsets.

The production procedure for delineation and depiction of dams and canal end/break points (above/below ground transition) is unlike that of other SD features in which positional accuracy is strictly upheld. Dam and canal lengths are often variable since they are roughly plotted to scale to provide a relative size. More emphasis is placed on the location/axis of these features rather than on their size/length.

Figure 1 depicts the data offset for an actual point bridge as observed on the Gatesville, Texas cell, map sheet 6446-1. The ITD bridge feature is approximately 25 meters from the road/stream crossing point where the field measurement took place. However, the actual position of the bridge may be as

close as 15 meters or as far as 35 meters from its intended location depending on the GPS error introduced in the field.

Table 2 illustrates various comparisons between the carto- and photo-controlled ITD at the thematic level. Carto feature offsets are acceptable, with some coverages performing better than others. For example, offsets for the carto transportation features averaged approximately 24 meters, while obstacles offsets approached 70 meters. The mean offset for the carto vegetation features (≈23m) was comparable to transportation but exhibited a much higher 95 percent confidence interval (≈22.5 vs. ≈4.5m). This indicates increased variability for the vegetation features and a potentially lower correlation with subsequent field observations.

Overall confidence intervals for the carto-controlled features ranged from ≈4m (transportation) to ≈53m (obstacles). The mean offset for the carto data is 28.8 meters. Conversely, the mean offsets of the photo-controlled features were very low across all thematic layers. They ranged from a low of 10-12 meters (vegetation, surface drainage, and transportation features) to a high of 21 meters (obstacles). The 95 percent confidence intervals are fairly consistent across features ranging from ≈6m (transportation) to ≈22 meters (obstacles). The mean offset for the photo data is 13.7 meters. This is directly attributable to the increased fidelity provided by a solely photogrammetric production technique.

It is recognized that statistics/comparisons for several feature groupings in Table 2 are based on small sample sizes (<30 observations). However, in each case the t-statistic exceeds the critical value, indicating that random error cannot explain the variance observed between the field data coordinates and those of ITD. Therefore, there is a significant difference between the populations at the 95 percent confidence level.

It should be noted that all of the ITD data used for this study was collected over CONUS areas with relatively reliable source materials. Assuming the availability of comparable sources, findings in this report should be extensible to any location. However, it is unknown to what extent, if any, foreign or other ancillary source materials may affect the results herein.

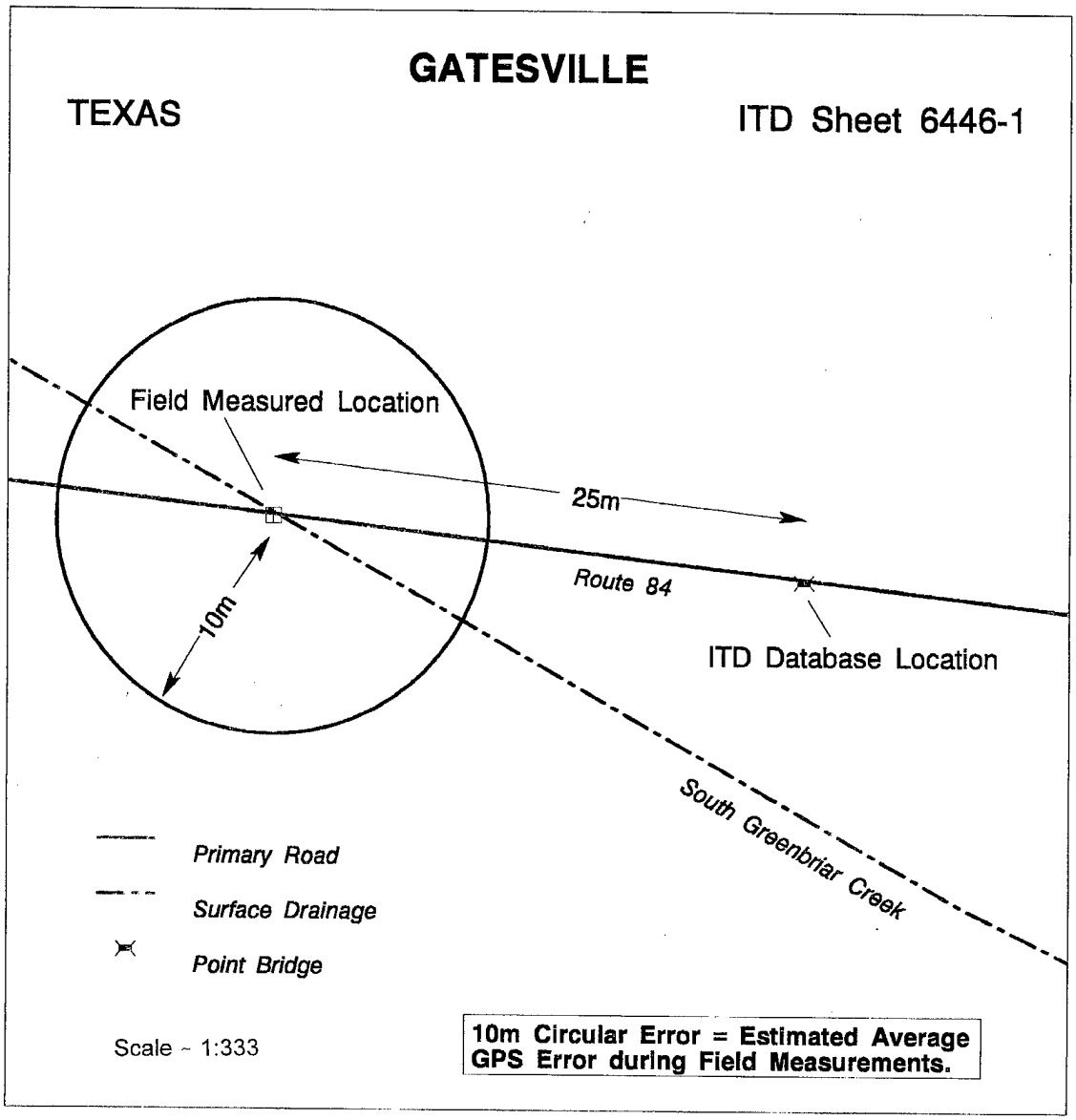


Figure 1. Data Point vs Field Point Offset

**Table 2.--Carto/Photo ITD vs. Field Data Offsets by Feature & Associated Statistics**

***Photo-Controlled Data in meters***

| *Measurement Type* | *Average (Mean)* | *Std. Dev.* | *95% Confidence Int. Of Mean* | *T Stat.* | *Crit. Val.* | *Sample Size* |
|---|---|---|---|---|---|---|
| All features | **13.72** | 19.49 | 10.98 - 16.47 | 9.8 | 1.65 | 196 |
| Trans-portation features | **12.69** | 17.29 | 9.69 - 15.69 | 8.37 | 1.66 | 130 |
| Obstacle features | **21.31** | 30.85 | 10.19 - 32.44 | 3.91 | 1.70 | 32 |
| Surf. Drainage features | **11.00** | 11.57 | 5.25 - 16.75 | 4.04 | 1.74 | 18 |
| Vegetation features | **10.00** | 9.56 | 4.91 - 15.09 | 4.19 | 1.75 | 16 |

***Carto-Controlled Data in meters***

| *Measurement Type* | *Average (Mean)* | *Std. Dev.* | *95% Confidence Int. Of Mean* | *T. Stat.* | *Crit. Val.* | *Sample Size* |
|---|---|---|---|---|---|---|
| All features | **28.76** | 32.25 | 26.27 - 31.25 | 22.67 | 1.65 | 646 |
| Trans-portation features | **24.43** | 24.97 | 22.20 - 26.65 | 21.61 | 1.65 | 488 |
| Obstacle features | **69.68** | 75.57 | 43.30 - 96.05 | 5.38 | 1.69 | 34 |
| Surf. Drainage features | **37.04** | 30.05 | 31.14 - 42.94 | 12.45 | 1.66 | 102 |
| Vegetation features | **23.27** | 25.42 | 12.00 - 34.54 | 4.29 | 1.72 | 22 |

## CONCLUSIONS

1. The offset of well-defined ITD features taken as a whole was approximately 25 meters. Approximately 90 percent of these features were within 50 meters of their expected locations. This meets the accuracy specification of 50 meters for a Class B, 1:50,000-scale TLM, a traditional source for targeting information.

2. Overall, carto-controlled ITD feature offsets (29 meters) were higher than photo-controlled ITD feature offsets (14 meters). Our expectations were that the photo-controlled ITD would perform very well, as it did; however, performance of the carto-controlled ITD was also suprisingly good.

3. The positional accuracy of ITD features was determined to be compatible with the positional accuracy of hand-held precise GPS equipment currently used in the field. This accuracy compatibility will lessen the chance for confusion and correlation problems, such as could occur when features are located close to one another on the ground and GPS-derived locations do not match data base locations. This problem may be more of a concern with lower accuracy data sets, such as VMap Level 1 (1:250,000 scale) and DCW (1:1,000,000 scale).

## LIST OF ACRONYMS

| | |
|---|---|
| AML | Arc Macro Language |
| $C^2$ | Command and Control |
| CONUS | Continental United States |
| DCAC | Digital Concepts and Analysis Center |
| DCW | Digital Chart of the World |
| DMA | Defense Mapping Agency |
| DOD | Department of Defense |
| E & N | Easting and Northing |
| FE | Feature Extraction |
| GPS | Global Positioning System |
| ITD | Interim Terrain Data |
| LAT/LONG | Latitude/Longitude |
| MC&G | Mapping, Charting, and Geodesy |
| OBS | Obstacles |
| PLGR | Precise Lightweight Global Positioning System Receiver |
| PPS | Precise Positioning Service |
| RMS | Root-Mean-Square |
| SD | Surface Drainage |
| TEC | Topographic Engineering Center |
| TLM | Topographic Line Map |
| TRANS | Transportation |
| TTADB | Tactical Terrain Analysis Data Base |
| TTD | Tactical Terrain Data |
| UTM | Universal Transverse Mercator |
| VEG | Vegetation |
| VMap | Vector Smart Map |
| WGS 84 | World Geodetic System 1984 |

## APPENDIX A. LIST OF FEATURES USED FOR ITD ACCURACY ANALYSIS

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6446-3 | Ft Hood, TX | Enbankment | 612236E<br>3439270N | 612211E<br>3439299 | Carto |
| | | Dam | 601152E<br>3440698N | 601138E<br>3440711N | |
| | | Canal | 615675E<br>3444048N | 615713E<br>3444142N | |
| | | Canal | 618715E<br>3445428N | 618703E<br>3445472 | |
| | | Dam | 614521E<br>3447867N | 614502E<br>3447927N | |
| | | Dam | 600534E<br>3451879N | 600551E<br>3451932N | |
| | | Dam | 603833E<br>3457106N | 603806E<br>3457133N | |
| | | Bridge | 612461E<br>3443791N | 612473E<br>3443782N | |
| | | Bridge | 602949E<br>3441761N | 602916E<br>3441715N | |
| | | Bridge | 596393E<br>3438843N | 596349E<br>3438820N | |
| | | Intersection | 598382E<br>3437559N | 598416E<br>3437602N | |
| | | Intersection | 603169E<br>3434389N | 603139E<br>3434362N | |
| | | Bridge | 603771E<br>3430498N | 603780E<br>3430492N | |
| | | Bridge | 606084E<br>3430848N | 606078E<br>3430860N | |
| | | Intersection | 608351E<br>3435176N | 608352E<br>3435157N | |
| | | Intersection | 610708E<br>3441426N | 610677E<br>3441406N | |
| | | Bridge | 611441E<br>3441161N | 611453E<br>3441160N | |
| | | Bridge | 614365E<br>3433882N | 614392E<br>3433891N | |
| | | Intersection | 618432E<br>3438905N | 618392E<br>3438916N | |
| | | Intersection | 617649E<br>3445778N | 617663E<br>3445792N | |
| | | Intersection | 610652E<br>3445582N | 610677E<br>3445620N | |
| | | Bridge | 612829E<br>3447389N | 612871E<br>3447448N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6646-3 | Ft Hood, TX | Intersection | 610243E 3452197N | 610210E 3452218N | Carto |
| | | Intersection | 610278E 3448437N | 610266E 3448446N | |
| | | Intersection | 609292E 3444767N | 609296E 3444794N | |
| | | Bridge | 606925E 3446290N | 606910E 3446331N | |
| | | Bridge | 606958E 3445267N | 606944E 3445289N | |
| | | RR Crossing | 604570E 3447927N | 604552E 3447966N | |
| | | Bridge | 601837E 3454347N | 601825E 3454364N | |
| | | RR Crossing | 600230E 3457508N | 600251E 3457491N | |
| | | Intersection | 599383E 3456696N | 599335E 3456773N | |
| | | Intersection | 596695E 3454347N | 596680E 3454364N | |
| | | Bridge | 601679E 3451879N | 601688E 3457491N | |
| | | Intersection | 603913E 3456696N | 603896E 3456773N | |
| | | Bridge | 603648E 3455382N | 603632E 3455381N | |
| | | Veg | 614601E 3443070N | 614492E 3443068N | |
| | | Veg | 614659E 3443335N | 614672E 3443378N | |
| | | Veg | 618071E 3438827N | 618133E 3438838N | |
| | | Veg | 618014E 3438659N | 617999E 3438658N | |
| 5154-3 | S. Pines, NC | Hedgerow | 647612E 3883884N | 647589E 3883900N | Carto |
| | | Hedgerow | 654834E 3875056N | 654598E 3875104N | |
| | | Escarpment | 653902E 3901450N | 653909E 3901480N | |
| | | Escarpment | 653318E 3901582N | 653398E 3901468N | |
| | | Hedgerow | 639646E 3888422N | 639651E 3888474N | |
| | | Dam | 658618E 3895060N | 658673E 3894973N | |
| | | Dam | 658491E 3895058N | 658440E 3894969N | |
| | | Dam | 647793E 3885606N | 647825E 3885555N | |
| | | Dam | 638742E 3885007N | 638710E 3884974N | |
| | | Dam | 638067E 3876549N | 638022E 3876521N | |
| | | Dam | 637986E 3876802N | 637946E 3876738N | |
| | | Dam | 655077E 3895868N | 655096E 3895795N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 5154-3 | S. Pines, NC | Dam | 644347E 3897558N | 644297E 3897527N | Carto |
| | | Dam | 641612E 3899349N | 641590E 3899308N | |
| | | Dam | 645541E 3890682N | 645530E 3890644N | |
| | | Culvert | 655308E 3892756N | 655308E 3892730N | |
| | | Bridge | 653375E 3891897N | 653381E 3891897N | |
| | | Intersection | 650815E 3891228N | 650811E 3891202N | |
| | | Intersection | 647444E 3890524N | 647475E 3890497N | |
| | | Intersection | 648608E 3884290N | 648634E 3884284N | |
| | | Culvert | 646803E 3882437N | 646825E 3882409N | |
| | | Intersection | 649561E 3876123N | 649581E 3876123N | |
| | | Culvert | 651602E 3875322N | 651598E 3875352N | |
| | | Intersection | 654536E 3875182N | 654547E 3875148N | |
| | | Bridge | 646894E 3875818N | 646886E 3875800N | |
| | | Bridge | 644370E 3879661N | 644388E 3879625N | |
| | | Bridge | 640181E 3883193N | 640164E 3883166N | |
| | | Bridge | 639308E 3883724N | 639293E 3883706N | |
| | | RR Bridge | 637964E 3879795N | 637950E 3879776N | |
| | | Intersection | 637041E 3880440N | 637045E 3880401N | |
| | | Intersection | 643237E 3882771N | 643240E 3882740N | |
| | | Bridge | 642069E 3876720N | 642059E 3876650N | |
| | | RR Crossing | 640897E 3875525N | 640904E 3875545N | |
| | | RR Crossing | 639850E 3875450N | 639821E 3875448N | |
| | | Bridge | 638787E 3877334N | 638764E 3877365N | |
| | | RR Crossing | 637723E 3877627N | 637743E 3877592N | |
| | | RR Crossing | 637251E 3879071N | 637260E 3879021N | |
| | | RR Crossing | 637106E 3879120N | 637139E 3879108N | |
| | | RR Crossing | 637722E 3877315N | 637762E 3877290N | |
| | | Intersection | 651349E 3882662N | 651380E 3882656N | |
| | | RR Crossing | 657343E 3883748N | 657359E 3883713N | |
| | | Intersection | 657709E 3880950N | 657703E 3880941N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 5154-3 | S. Pines, NC | Bridge | 649989E<br>3891562N | 649982E<br>3891533N | Carto |
| | | RR Crossing | 646665E<br>3893685N | 646684E<br>3893630N | |
| | | RR Bridge | 645701E<br>3892795N | 645722E<br>3892759N | |
| | | Intersection | 658668E<br>3898187N | 658662E<br>3898177N | |
| | | Culvert | 657110E<br>3899111N | 657113E<br>3899107N | |
| | | Intersection | 654251E<br>3900762N | 654265E<br>3900776N | |
| | | Bridge | 654991E<br>3901200N | 655002E<br>3901185N | |
| | | Intersection | 648893E<br>3901028N | 648890E<br>3901013N | |
| | | Bridge | 649381E<br>3898330N | 649334E<br>3898362N | |
| | | Intersection | 649467E<br>3896655N | 649481E<br>3896623N | |
| | | Bridge | 646070E<br>3898360N | 646048E<br>3898381N | |
| | | Intersection | 641145E<br>3896577N | 641161E<br>3896535N | |
| | | Intersection | 640958E<br>3899258N | 640955E<br>3899221N | |
| | | Bridge | 641272E<br>3900515N | 641253E<br>3900472N | |
| | | Bridge | 637627E<br>3899910N | 637601E<br>3899853N | |
| | | Culvert | 638452E<br>3898448N | 638471E<br>3898393N | |
| | | Intersection | 638789E<br>3895800N | 638785E<br>3895780N | |
| | | Bridge | 643040E<br>3893622N | 643026E<br>3893651N | |
| | | Bridge | 637160E<br>3891736N | 637101E<br>3891732N | |
| | | Intersection | 639767E<br>3890356N | 639766E<br>3890313N | |
| | | Culvert | 641248E<br>3888409N | 641229E<br>3888388N | |
| | | RR Bridge | 643012E<br>3888869N | 643006E<br>3888860N | |
| | | RR Bridge | 643626E<br>3889215N | 643592E<br>3889191N | |
| | | Veg | 643250E<br>3896449N | 643227E<br>3896392N | |
| 6446-1 | Gtsvlle, TX | Embankment | 636020E<br>3474037N | 635832E<br>3474032N | Carto |
| | | Embankment | 623743E<br>3469601N | 623750E<br>3469537N | |
| | | Embankment | 623335E<br>3470156N | 623336E<br>3470120N | |
| | | Dam | 620569E<br>3483618N | 620544E<br>3483606N | |
| | | Dam | 632108E<br>3480786N | 632133E<br>3480787N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6446-1 | Gtsvlle, TX | Dam | 621354E 3475762N | 621382E 3475745N | Carto |
| | | Intersection | 619358E 3478498N | 619373E 3478474N | |
| | | Intersection | 620154E 3483541N | 620186E 3483519N | |
| | | Bridge | 619546E 3484672N | 619525E 3484708N | |
| | | Bridge | 625009E 3485357N | 625002E 3485309N | |
| | | Culvert | 630407E 3482051N | 630387E 3482057N | |
| | | Bridge | 627952E 3477804N | 627927E 3477791N | |
| | | Bridge | 633273E 3477574N | 633281E 3477550N | |
| | | Bridge | 637903E 3478469N | 637918E 3478474N | |
| | | Culvert | 639389E 3481077N | 639421E 3481101N | |
| | | Intersection | 639745E 3482187N | 639758E 3482189N | |
| | | Bridge | 637139E 3485114N | 637128E 3485125N | |
| | | Intersection | 642206E 3484883N | 642217E 3484848N | |
| | | Bridge | 642108E 3485294N | 642124E 3485254N | |
| | | RR Crossing | 641872E 3476955N | 641891E 3476904N | |
| | | Intersection | 640600E 3472100N | 640617E 3472072N | |
| | | Bridge | 639334E 3472937N | 639379E 3472957N | |
| | | Bridge | 636034E 3472727N | 636102E 3472772N | |
| | | Bridge | 633134E 3474033N | 633145E 3474058N | |
| | | Bridge | 633344E 3474034N | 633357E 3474054N | |
| | | Intersection | 631370E 3473751N | 631425E 3473750N | |
| | | Bridge | 627608E 3474296N | 627610E 3474310N | |
| | | RR Crossing | 624019E 3475633N | 624032E 3475665N | |
| | | Bridge | 623346E 3473061N | 623365E 3473055N | |
| | | Bridge | 623469E 3472803N | 623491E 3472751N | |
| | | Intersection | 623801E 3472078N | 623848E 3472044N | |
| | | Bridge | 620781E 3470228N | 620780E 3470200N | |
| | | RR Crossing | 625162E 3470791N | 625151E 3470705N | |
| | | RR Crossing | 626392E 3470036N | 626363E 3470048N | |
| | | RR Crossing | 626091E 3470600N | 626037E 3470645N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6446-1 | Gtsvlle, TX | RR Crossing | 627009E<br>3471319N | 627054E<br>3471307N | Carto |
| | | RR Crossing | 626559E<br>3472283N | 626572E<br>3472256N | |
| | | Intersection | 628417E<br>3466272N | 628471E<br>3466246N | |
| | | Bridge | 629100E<br>3467627N | 629136E<br>3467650N | |
| | | Intersection | 629588E<br>3469356N | 629617E<br>3469327N | |
| | | RR Crossing | 629864E<br>3464385N | 629840E<br>3464390N | |
| | | Intersection | 631809E<br>3463629N | 631833E<br>3463621N | |
| | | Bridge | 633558E<br>3460735N | 633508E<br>3460726N | |
| | | Intersection | 635882E<br>3458878N | 635901E<br>3458832N | |
| | | Intersection | 641192E<br>3460735N | 641155E<br>3460789N | |
| | | Bridge | 632954E<br>3469163N | 632966E<br>3469164N | |
| | | Intersection | 635168E<br>3468303N | 635197E<br>3468295N | |
| | | Bridge | 639842E<br>3469409N | 639826E<br>3469390N | |
| | | Bridge | 639694E<br>3469618N | 639680E<br>3469578N | |
| | | Veg | 620448E<br>3478827N | 620457E<br>3478835N | |
| 6446-2 | Kileen, TX | Fence | 621510E<br>3445934N | 621606E<br>3446019N | Carto |
| | | Dam | 640448E<br>3433611N | 640382E<br>3433555N | |
| | | Dam | 640033E<br>3432615N | 639989E<br>3432595N | |
| | | Dam | 623227E<br>3437054N | 623202E<br>3437098N | |
| | | Dam | 632025E<br>3448194N | 631960E<br>3448164N | |
| | | Dam | 636824E<br>3445119N | 636817E<br>3445130N | |
| | | Dam | 634618E<br>3438880N | 634648E<br>3438823N | |
| | | Dam | 633533E<br>3442258N | 633558E<br>3442222N | |
| | | Dam | 626060E<br>3439811N | 626031E<br>3439792N | |
| | | Dam | 625992E<br>3439862N | 625963E<br>3439834N | |
| | | Dam | 625924E<br>3439894N | 625875E<br>3439889N | |
| | | Canal | 621810E<br>3444471N | 621691E<br>3444570N | |
| | | Dam | 623546E<br>3445851N | 623579E<br>3445841N | |
| | | Intersection | 640647E<br>3434695N | 640614E<br>3434707N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6446-2 | Kileen, TX | Intersection | 633937E 3436873N | 633905E 3436973N | Carto |
| | | Intersection | 629191E 3436217N | 629161E 3436221N | |
| | | Bridge | 628739E 3431566N | 628721E 3431590N | |
| | | Bridge | 629368E 3431225N | 629394E 3431229N | |
| | | Bridge | 627409E 3434251N | 627354E 3434228N | |
| | | Intersection | 624917E 3433549N | 624898E 3433540N | |
| | | Intersection | 620823E 3433556N | 620807E 3433539N | |
| | | Intersection | 619490E 3436219N | 619474E 3436224N | |
| | | Intersection | 622900E 3447695N | 622930E 3447690N | |
| | | Intersection | 631809E 3448350N | 631786E 3448355N | |
| | | Intersection | 630910E 3450406N | 630895E 3450380N | |
| | | Culvert | 629653E 3452862N | 629598E 3452741N | |
| | | Bridge | 629913E 3453300N | 629838E 3453181N | |
| | | Bridge | 632545E 3447583N | 632548E 3447578N | |
| | | Intersection | 641494E 3441626N | 641497E 3441617N | |
| | | Bridge | 640503E 3440679N | 640474E 3440665N | |
| | | RR Crossing | 639165E 3439701N | 639176E 3439680N | |
| | | Bridge | 635613E 3437928N | 635664E 3437906N | |
| | | Bridge | 635528E 3437969N | 635387E 3438032N | |
| | | RR Bridge | 633503E 3438800N | 633458E 3438828N | |
| | | Bridge | 634536E 3440113N | 634510E 3440074N | |
| | | Bridge | 625171E 3441837N | 625192E 3441821N | |
| | | Bridge | 625085E 3441773N | 625084E 3441761N | |
| | | Bridge | 623935E 3442572N | 623894E 3442573N | |
| | | Bridge | 622830E 3443032N | 622848E 3443087N | |
| | | RR Crossing | 621484E 3443444N | 621384E 3443498N | |
| | | RR Bridge | 619344E 3443784N | 619345E 3443804N | |
| | | Bridge | 639590E 3456637N | 639593E 3456613N | |
| | | RR Crossing | 641437E 3456560N | 641457E 3456642N | |
| | | Bridge | 642220E 3456627N | 642236E 3456551N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6446-2 | Kileen, TX | Culvert | 642376E<br>3456891N | 642360E<br>3456854N | Carto |
| | | Veg | 623892E<br>3436271N | 623904E<br>3436241N | |
| | | Veg | 624085E<br>3436352N | 624080E<br>3436333N | |
| 6446-4 | Purmela, TX | Escarpment | 614325E<br>3459098N | 614357E<br>3459074N | Carto |
| | | Dam | 611342E<br>3462480N | 611279E<br>3462665N | |
| | | Dam | 598636E<br>3470160N | 598624E<br>3470168N | |
| | | Dam | 618222E<br>3472729N | 618225E<br>3472777N | |
| | | Dam | 597188E<br>3482222N | 597165E<br>3482238N | |
| | | RR Crossing | 611766E<br>3460071N | 611800E<br>3460079N | |
| | | Intersection | 612071E<br>3461831N | 612098E<br>3461799N | |
| | | Intersection | 603726E<br>3459003N | 603739E<br>3459025N | |
| | | Intersection | 597701E<br>3461129N | 597673E<br>3461123N | |
| | | Bridge | 606178E<br>3461767N | 606141E<br>3461710N | |
| | | Bridge | 606239E<br>3461871N | 606216E<br>3461846N | |
| | | Intersection | 605810E<br>3461088N | 605780E<br>3461103N | |
| | | Intersection | 601294E<br>3467052N | 601295E<br>3467060N | |
| | | Bridge | 595896E<br>3467660N | 595905E<br>3467660N | |
| | | Bridge | 602910E<br>3471970N | 602964E<br>3471972N | |
| | | Bridge | 602994E<br>3471984N | 603073E<br>3471992N | |
| | | Bridge | 610876E<br>3474273N | 610892E<br>3474292N | |
| | | Intersection | 613390E<br>3474034N | 613364E<br>3474044N | |
| | | Intersection | 608913E<br>3468643N | 608904E<br>3468636N | |
| | | Culvert | 616790E<br>3469255N | 616829E<br>3469245N | |
| | | Intersection | 615598E<br>3468910N | 615618E<br>3468933N | |
| | | Bridge | 618213E<br>3466087N | 618238E<br>3466071N | |
| | | Intersection | 617535E<br>3462579N | 617561E<br>3462561N | |
| | | RR Crossing | 614417E<br>3476328N | 614400E<br>3476383N | |
| | | Bridge | 615053E<br>3478377N | 615049E<br>3478380N | |
| | | Intersection | 611844E<br>3478834N | 611749E<br>3478787N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 6446-4 | Purmela, TX | Culvert | 608495E 3478687N | 608500E 3478675N | Carto |
| | | Bridge | 601335E 3475281N | 601358E 3475301N | |
| | | Intersection | 604494E 3480033N | 604445E 3480036N | |
| | | Culvert | 603191E 3480475N | 603199E 3480468N | |
| | | Culvert | 603640E 3480307N | 603636E 3480301N | |
| | | Bridge | 596928E 3479897N | 596888E 3479909N | |
| | | Intersection | 598572E 3483744N | 598555E 3483754N | |
| | | Bridge | 598511E 3483850N | 598528E 3483843N | |
| | | Bridge | 605711E 3484555N | 605677E 3484559N | |
| | | Bridge | 608088E 3485626N | 608040E 3485561N | |
| | | Intersection | 609356E 3483656N | 609317E 3483660N | |
| | | Bridge | 614235E 3483123N | 614253E 3483110N | |
| | | RR Crossing | 613555E 3483499N | 613511E 3483533N | |
| | | Intersection | 617119E 3478496N | 617115E 3478477N | |
| | | Bridge | 617687E 3478481N | 617759E 3478487N | |
| | | Bridge | 617983E 3478483N | 618053E 3478481N | |
| | | Veg | 602766E 3476602N | 602784E 3476574N | |
| | | Veg | 602524E 3475830N | 602520E 3475851N | |
| 5254-3 | Fayetvlle, NC | Hedgerow | 698560E 3902238N | 698527E 3902260N | Carto |
| | | Hedgerow | 698828E 3902418N | 698767E 3902433N | |
| | | Embankment | 688976E 3887458N | 689046E 3887404N | |
| | | Hedgerow | 690583E 3882709N | 690505E 3882788N | |
| | | Hedgerow | 695243E 3881569N | 695301E 3881688N | |
| | | Escarpment | 701409E 3885266N | 701070E 3885043N | |
| | | Dam | 687376E 3890552N | 687369E 3890577N | |
| | | Dam | 687378E 3890408N | 687361E 3890435N | |
| | | Dam | 685796E 3901018N | 685824E 3901008N | |
| | | Dam | 687228E 3901251N | 687217E 3901230N | |
| | | Dam | 688213E 3902275N | 688235E 3902272N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 5254-3 | Fayetvlle, NC | Dam | 691884E 3899280N | 691885E 3899222N | Carto |
| | | Dam | 692141E 3899452N | 692149E 3899395N | |
| | | Dam | 698946E 3900134N | 698907E 3900074N | |
| | | Dam | 698892E 3900002N | 698876E 3899957N | |
| | | Canal | 686771E 3881603N | 686641E 3881644N | |
| | | Dam | 684201E 3878045N | 684195E 3878042N | |
| | | Dam | 684091E 3878069N | 684101E 3878080N | |
| | | Dam | 684195E 3875250N | 684193E 3875266N | |
| | | Dam | 689552E 3881090N | 689512E 3881160N | |
| | | RR Crossing | 684338E 3888530N | 684342E 3888511N | |
| | | RR Bridge | 686700E 3890292N | 686703E 3890319N | |
| | | RR Crossing | 687316E 3889569N | 687653E 3889590N | |
| | | RR Crossing | 688731E 3889699N | 688709E 3889692N | |
| | | Intersection | 683262E 3889916N | 683238E 3889901N | |
| | | Intersection | 684994E 3891858N | 684962E 3891890N | |
| | | RR Crossing | 684729E 3892798N | 684704E 3892772N | |
| | | Intersection | 684620E 3893506N | 684601E 3893596N | |
| | | Bridge | 683239E 3896469N | 683215E 3896468N | |
| | | Bridge | 683398E 3896352N | 683384E 3896312N | |
| | | Bridge | 686364E 3897405N | 686401E 3897505N | |
| | | Bridge | 687778E 3899046N | 687773E 3899042N | |
| | | Intersection | 684902E 3901451N | 684890E 3901481N | |
| | | Intersection | 687929E 3900666N | 687918E 3900664N | |
| | | Intersection | 692663E 3901641N | 692689E 3901635N | |
| | | Bridge | 693068E 3900799N | 693090E 3900774N | |
| | | Intersection | 689555E 3894894N | 689558E 3894873N | |
| | | Intersection | 695794E 3897946N | 695811E 3897963N | |
| | | Intersection | 699284E 3900244N | 699270E 3900248N | |
| | | RR Crossing | 702077E 3897360N | 702057E 3897339N | |
| | | Intersection | 696830E 3895386N | 696836E 3895374N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 5254-3 | Fayetvlle, NC | RR Crossing | 694982E<br>3893758N | 694960E<br>3893761N | Carto |
| | | Intersection | 696860E<br>3892900N | 696859E<br>3892911N | |
| | | RR Bridge | 695196E<br>3891817N | 695214E<br>3891849N | |
| | | Intersection | 691516E<br>3886491N | 691536E<br>3886483N | |
| | | Bridge | 689225E<br>3884899N | 689228E<br>3884890N | |
| | | Intersection | 685145E<br>3885782N | 685154E<br>3885806N | |
| | | Intersection | 683336E<br>3883675N | 683345E<br>3883685N | |
| | | Bridge | 684484E<br>3883110N | 684491E<br>3883103N | |
| | | Intersection | 684609E<br>3879853N | 684584E<br>3879842N | |
| | | Bridge | 684470E<br>3875250N | 684435E<br>3875266N | |
| | | Intersection | 685474E<br>3875462N | 685518E<br>3875502N | |
| | | RR Bridge | 689469E<br>3876917N | 689511E<br>3876932N | |
| | | Intersection | 688309E<br>3879937N | 688355E<br>3879907N | |
| | | Intersection | 688481E<br>3882056N | 688491E<br>3882070N | |
| | | Intersection | 693415E<br>3882420N | 693417E<br>3882320N | |
| | | Bridge | 695736E<br>3881689N | 695661E<br>3881649N | |
| | | Bridge | 695442E<br>3881606N | 695513E<br>3881603N | |
| | | Bridge | 695343E<br>3880735N | 695359E<br>3880736N | |
| | | Bridge | 695514E<br>3880658N | 695543E<br>3880654N | |
| | | Bridge | 698873E<br>3876023N | 698861E<br>3876071N | |
| | | Bridge | 701832E<br>3877111N | 701843E<br>3877130N | |
| | | Intersection | 703153E<br>3875945N | 703142E<br>3875956N | |
| | | Intersection | 703734E<br>3883561N | 703697E<br>3883595N | |
| | | Intersection | 704652E<br>3889022N | 704593E<br>3889016N | |
| | | RR Crossing | 700507E<br>3888062N | 700524E<br>3888038N | |
| | | Intersection | 702567E<br>3891612N | 702564E<br>3891625N | |
| | | Bridge | 704579E<br>3894461N | 704576E<br>3894457N | |
| | | Intersection | 696703E<br>3888154N | 696694E<br>3888157N | |
| | | RR Crossing | 696189E<br>3884635N | 696203E<br>3884614N | |
| | | Veg | 687869E<br>3889309N | 687881E<br>3889315N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 4649-3 | Sn Diego Mt, NM | Embankment | 319694E 3602811N | 319669E 3602917N | Photo |
| | | Embankment | 319902E 3602289N | 319986E 3602169N | |
| | | Dam | 312677E 3601301N | 312693E 3601267N | |
| | | Bridge | 318908E 3597557N | 318897E 3597589N | |
| | | Bridge | 313092E 3601316N | 313098E 3601324N | |
| | | Bridge | 312608E 3602266N | 312608E 3602260N | |
| | | RR Bridge | 312551E 3610308N | 312559E 3610307N | |
| | | Intersection | 314258E 3618851N | 314234E 3618851N | |
| | | Intersection | 315469E 3618890N | 315426E 3618900N | |
| | | Intersection | 318688E 3618948N | 318660E 3618974N | |
| | | Intersection | 316283E 3611107N | 316278E 3611093N | |
| | | Intersection | 318512E 3606332N | 318488E 3606327N | |
| | | Intersection | 320260E 3602535N | 320250E 3602550N | |
| | | Intersection | 320868E 3601240N | 320871E 3601236N | |
| | | Bridge | 320620E 3600195N | 320595E 3600185N | |
| | | Veg | 317143E 3605719N | 317127E 3605715N | |
| 4648-3 | Afton, NM | Canal | 330578E 3567167N | 330575E 3567161N | Photo |
| | | Intersection | 334762E 3563269N | 334753E 3563267N | |
| | | Intersection | 334604E 3563591N | 334599E 3563595N | |
| | | Bridge | 334246E 3563617N | 334242E 3563605N | |
| | | RR Crossing | 333868E 3561458N | 333862E 3561455N | |
| | | Bridge | 334169E 3564683N | 334167E 3564678N | |
| | | Bridge | 334250E 3565450N | 334250E 3565450N | |
| | | Bridge | 334260E 3565560N | 334261E 3565569N | |
| | | Bridge | 334302E 3566048N | 334301E 3566053N | |
| | | Intersection | 334400E 3567184N | 334388E 3567199N | |
| | | Intersection | 333706E 3568456N | 333713E 3568454N | |
| 4648-1 | Organ Peak, NM | Fence | 348364E 3595868N | 348391E 3595854N | Photo |
| | | Embankment | 336249E 3576812N | 336255E 3576807N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 4648-1 | Organ Peak, NM | Embankment | 336390E<br>3576960N | 336407E<br>3576951N | Photo |
| | | Embankment | 335877E<br>3576752N | 335894E<br>3576736N | |
| | | Embankment | 337332E<br>3574594N | 337333E<br>3574599N | |
| | | Canal | 338617E<br>3595980N | 338621E<br>3595963N | |
| | | Canal | 338639E<br>3596409N | 338629E<br>3596409N | |
| | | Dam | 338854E<br>3577645N | 338854E<br>3577660N | |
| | | Dam | 342513E<br>3579290N | 342515E<br>3579298N | |
| | | Dam | 339300E<br>3579062N | 339287E<br>3579063N | |
| | | Dam | 339865E<br>3582598N | 339872E<br>3582595N | |
| | | Culvert | 357102E<br>3589906N | 357110E<br>3589890N | |
| | | Bridge | 355954E<br>3589884N | 355968E<br>3589868N | |
| | | Bridge | 354952E<br>3589866N | 354975E<br>3589849N | |
| | | Bridge | 350363E<br>3588951N | 350376E<br>3588962N | |
| | | Intersection | 348340E<br>3588354N | 348325E<br>3588366N | |
| | | Culvert | 348322E<br>3594259N | 348338E<br>3594252N | |
| | | Intersection | 341697E<br>3585625N | 341703E<br>3585601N | |
| | | Intersection | 337347E<br>3583917N | 337310E<br>3583881N | |
| | | Intersection | 337717E<br>3586795N | 337693E<br>3586772N | |
| | | Bridge | 337324E<br>3590839N | 337327E<br>3590825N | |
| | | Bridge | 337042E<br>3593026N | 337034E<br>3593054N | |
| | | Bridge | 336905E<br>3593917N | 336922E<br>3593917N | |
| | | Intersection | 336721E<br>3595366N | 336724E<br>3595367N | |
| | | Bridge | 335389E<br>3576897N | 335416E<br>3576905N | |
| | | Intersection | 338398E<br>3577631N | 338408E<br>3577616N | |
| | | Intersection | 341626E<br>3578993N | 341626E<br>3578987N | |
| | | Intersection | 336695E<br>3573853N | 336700E<br>3573836N | |
| | | Intersection | 343152E<br>3575268N | 343276E<br>3575286N | |
| | | Intersection | 346998E<br>3577994N | 347040E<br>3577887N | |
| | | RR Crossing | 350275E<br>3578157N | 350265E<br>3578121N | |
| | | Veg | 342194E<br>3592762N | 342202E<br>3592755N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 4648-1 | Organ Peak, NM | Veg | 342586E 3592754N | 342600E 3592752N | Photo |
| | | Veg | 340689E 3584703N | 340689E 3584715N | |
| | | Veg | 340522E 3584706N | 340487E 3584716N | |
| | | Veg | 340494E 3584325N | 340484E 3584311N | |
| | | Veg | 340686E 3584316N | 340681E 3584308N | |
| | | Veg | 335375E 3569766N | 335373E 3569762N | |
| 4749-1 | Hollomn AFB, NM | Embankment | 394613E 3634347N | 394605E 3634334N | Photo |
| | | Embankment | 394745E 3633743N | 394737E 3633746N | |
| | | Escarpment | 394647E 3639836N | 394648E 3639797N | |
| | | Fence | 397025E 3638228N | 397033E 3638228N | |
| | | Fence | 397514E 3638265N | 397516E 3638267N | |
| | | Fence | 398544E 3637871N | 398552E 3637868N | |
| | | Fence | 398544E 3638334N | 398562E 3638324N | |
| | | Escarpment | 397616E 3640263N | 397603E 3640247N | |
| | | Escarpment | 401876E 3644321N | 401945E 3644316N | |
| | | Canal | 397784E 3633706N | 397827 3633713N | |
| | | Bridge | 400204E 3633233N | 400208E 3633205N | |
| | | Intersection | 399103E 3634194N | 399088E 3634186N | |
| | | Bridge | 398656E 3632375N | 398657E 3632373N | |
| | | Intersection | 398680E 3632334N | 398684E 3632334N | |
| | | Intersection | 393443E 3629277N | 393443E 3629255N | |
| | | Intersection | 390214E 3627364N | 390209E 3627345N | |
| | | Intersection | 387538E 3628968N | 387540E 3628960N | |
| | | Intersection | 405318E 3635535N | 405350E 3635571N | |
| | | Bridge | 397268E 3632966N | 397270E 3632961N | |
| | | RR Crossing | 393571E 3634483N | 393577E 3634476N | |
| | | Intersection | 395407E 3637829N | 395409E 3637828N | |
| | | Bridge | 392789E 3640877N | 392797E 3640877N | |
| | | Bridge | 392581E 3644460N | 392575E 3644457N | |

| Sheet | Sheet Name/St. | Feature | UTM Coordinates Field | UTM Coordinates Digital File | Control Source |
|---|---|---|---|---|---|
| 4749-1 | Hollomn, NM | Bridge | 392524E<br>3645393N | 392522E<br>3645393N | Photo |
| | | Bridge | 392365E<br>3648006N | 392367E<br>3648006N | |
| | | RR Crossing | 392435E<br>3639098N | 392441E<br>3639104N | |
| | | Intersection | 393792E<br>3642802N | 393792E<br>3642818N | |
| | | Intersection | 393802E<br>3645964N | 393804E<br>3645919N | |
| | | RR Crossing | 398914E<br>3634658N | 398943E<br>3634722N | |
| | | RR Crossing | 400107E<br>3635825N | 400111E<br>3635831N | |
| | | Intersection | 397853E<br>3641726N | 397858E<br>3641736N | |
| | | RR Bridge | 406519E<br>3651646N | 406516E<br>3651642N | |
| | | Intersection | 404539E<br>3646317N | 404538E<br>3646318N | |

## APPENDIX B. STATISTICAL EXPLANATIONS

**Sample Size/Mean** - For this study, sample size is the number of northings and eastings in a given data grouping. A single sample represents the difference in meters between the field coordinates and the photo/carto-controlled ITD coordinates at a specific point. Mean was determined by taking the sum of all errors and dividing by the sample size.

**Standard Deviation** - A measure indicating the extent to which the data values are distributed about the mean. In a normal distribution, 68 percent of all values should fall within one standard deviation of the mean. The standard deviation is proportional to the sum of the difference between each value and the mean squared.

**95 Percent Confidence Interval** - Indicates, with 95 percent certainty, the range in which the mean is situated.

**T-statistic/Critical Value** - This statistic is dependent upon sample size and determines the probability that the actual variance observed can be solely explained by random error. The critical value is the threshold that the T-statistic must exceed, at a given confidence level and sample size, to ensure rejection of the null hypothesis (i.e., for this study, that there is no difference between the field data coordinates and those of the ITD data). Therefore, for a given sample size of >30 observations, a t-statistic of ≈1.65 represents a 0.05 probability that the measured error is solely random. A t-statistic of 2.58 represents a 0.005 probability of random error and a t-statistic of 6.90 represents a $5.48$ by $10^{-10}$ probability. For smaller sample sizes (15 to 30 observations), a t-statistic of ≈1.75 will yield similar probabilities. A large t-statistic indicates that the error found is real (not random) and ensures the validity of comparisons between varying sample sizes.